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New Era in Likelihood Analyses of the Local Group Acceleration

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Abstract. In maximum-likelihood analyses of the Local Group (LG) acceleration, the object describing nonlinear effects is the *coherence function* (CF), i.e. the cross-correlation coefficient of the Fourier modes of the velocity and gravity fields. We study the CF numerically, using a hydrodynamic code. The only cosmological parameter that the CF is strongly sensitive to is the normalization σ_8 of the underlying density field. We provide an analytical fit for the CF as a function of σ_8 and the wavevector. The characteristic decoherence scale which our formula predicts is an order of magnitude smaller than that determined by Strauss et al. This implies that present likelihood constraints on cosmological parameters from analyses of the LG acceleration are significantly tighter than hitherto reported.

1. Introduction

Comparisons between the CMB dipole and the Local Group (LG) gravitational acceleration can serve not only as a test for the kinematic origin of the former but also as a constraint on cosmological parameters. A commonly applied method of constraining the parameters by the LG velocity–gravity comparison is a maximum-likelihood analysis (Strauss et al. 1992, hereafter S92). In such an analysis, a proper object describing nonlinear effects is the *coherence function* (CF),

$$C(\mathbf{k}) = \frac{\langle \mathbf{g_k} \cdot \mathbf{v_k^\star} \rangle}{\langle |\mathbf{g_k}|^2 \rangle^{1/2} \langle |\mathbf{v_k}|^2 \rangle^{1/2}}\,, \tag{1}$$

where $\mathbf{g_k}$ and $\mathbf{v_k}$ are the Fourier components of the gravity and velocity fields, and $\langle \ldots \rangle$ means the ensemble averaging.

2. Results of numerical simulations

We model cold dark matter as a pressureless fluid. We chose to use a grid-based code rather than a N-body code because it directly produces a volume-weighted velocity field, as required here.

We checked that the CF depends on Ω_m very weakly. Next, we tested its dependence on the normalization of the power spectrum. We found that the dependence of the function on σ_8 and the wavevector can be well modelled as

$$C(k) = \exp\left(-ak\right)\,, \tag{2}$$

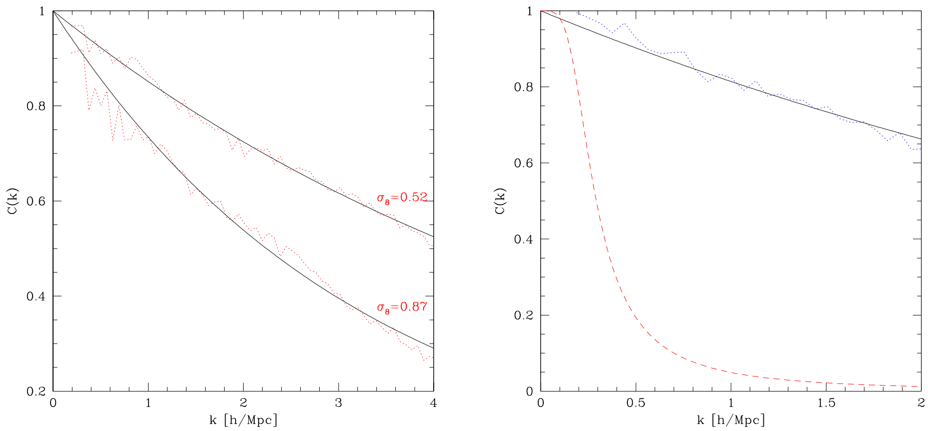

Figure 1. *Left:* The coherence function for cluster normalizations of the PSCz power spectrum. Dotted lines show the function from numerical simulations, while solid ones are our fits. *Right:* The function for a standard CDM cosmological model with $\sigma_8 = 0.625$. Dotted: numerical simulations, solid: our fit. The dashed line is the formula (18) of S92, with $r_c = 4.5\ h^{-1}\,$Mpc.

where

$$a = \begin{cases} 0.757\ \sigma_8^2 & \text{for } \sigma_8 \leq 0.3\,, \\ -0.059 + 0.423\ \sigma_8 & \text{for } 0.3 < \sigma_8 \leq 1.0\,. \end{cases} \tag{3}$$

In the left panel of Figure 1 we show the CF for the values of σ_8 given by the cluster normalization, for flat models with $\Omega_m = 1$ and $\Omega_m = 0.3$, respectively. Dotted lines show the function from numerical simulations, while solid ones are our fits. The fits are good; we checked that for other values of σ_8 they are as good as those shown here.

The CF has been modelled by S92, who calibrated it so as to fit the results of N-body simulations of a standard CDM cosmology. In the right panel of Figure 1 we show S92's prediction for the function, as well as our results, for the standard CDM power spectrum and σ_8 normalization of S92 (0.625). The discrepancy of our results with the formula of S92 is drastic! Instead of a characteristic decoherence scale of 4.5 $h^{-1}\,$Mpc (S92), our formula suggests a fraction of a megaparsec.

Greater coherence of the LG velocity with the LG gravity implies tighter constraints on cosmological parameters that can be obtained from their comparison. Thus, *in likelihood analyses of the LG acceleration, the value of β can be determined with significantly greater precision than is currently believed.*

References

Strauss M.A., Yahil A., Davis M., Huchra J.P., Fisher K., 1992, ApJ, 397, 395 (S92)